CLAIMS

WHAT IS CLAIMED IS:

1. A method for solid free-form fabrication of a three-dimensional metal object, comprising:

depositing a particulate blend in a defined region, said particulate blend including a number of metal or metal alloy particulates and a peroxide; and

selectively ink-jetting a binder system onto a predetermined area of said particulate blend to form a green part, wherein said binder system includes a water soluble monofunctional acrylate-based monomer, a water soluble difunctional acrylate-based monomer, an amine, and water.

2. The method of claim 1, further comprising removing said green part from said particulate blend.

3. The method of claim 1, further comprising performing a thermal binder burnout process on said green part.

4. The method of claim 3, wherein said thermal binder burnout process removes an organic content from said green part.

5. The method of claim 4, wherein said thermal binder burnout process comprises applying thermal energy to said green part.

6. The method of claim 4, further comprising performing a sintering process on said green part after said thermal binder burnout process.

7. The method of claim 5, wherein said sintering process comprises providing thermal energy to said green part sufficient to sinter said metal or metal alloy particulates.

8. The method of claim 1, wherein said binder system is selectively ink-jetted onto said particulate blend by one of a thermally actuated inkjet dispenser, a mechanically actuated inkjet dispenser, an electrostatically actuated inkjet dispenser, a magnetically actuated inkjet dispenser, a piezoelectrically actuated inkjet dispenser, or a continuous inkjet dispenser.

9. The method of claim 1, wherein said metal or metal alloy particulates comprises one of a stainless steel alloy, a magnetic alloy, a cobalt alloy, copper, a copper alloy, bronze, brass, tin, gold, iron, silver, platinum, palladium, iridium, titanium, tantalum, chromium alloys, an aluminum alloy, a magnesium alloy, an iron alloy, a nickel alloy, a silicon alloy, a zirconium alloy, a gold alloy, or metal coated ceramic particulates.

10. The method of claim 1, wherein said peroxide comprises one of a methyl ethyl ketone peroxide, a benzoyl peroxide, an acetylacetone peroxide, or a cumene hydroperoxide.

11. The method of claim 1, wherein said water soluble monofunctional acrylate-based monomer comprises one of an ester of acrylic or a methacrylic acid.

12. The method of claim 1, wherein said water soluble difunctional acrylate-based monomer comprises one of a 1,4-butanediol diacrylate, a 1,4-butanediol dimethacrylate, a 1,6-hexamethylene glycol diacrylate, a neopentyl glycol dimethacrylate, a trimethylol propane trimethacrylate, a pentaerythritol triacrylate, a penta-erythritol trimethacrylate, a triethylene glycol triacrylate, a triethylene glycol trimethacrylate, a urethane acrylate, a trimethylol propane triacrylate, or a urethane methacrylate.

13. The method of claim 1, wherein said amine comprises an aromatic amine.

14. The method of claim 13, wherein said aromatic amine comprises one of a dimethylamino benzoate, dihydroxyethyl-p-toluidine, dimethylaniline, a diethylaniline, or a dimethylacetamide.

15. The method of claim 1, wherein said particulate blend comprises 99% by weight 434 stainless steel metal-based powder and 1% benzoyl peroxide.

16. The method of claim 1, wherein said particulate blend comprises 95 to 99.5% 410 stainless steel metal-based powder and 1% benzoyl peroxide.

17. The method of claim 1, wherein said binder system comprises:
10 to 40% glycerol dimethacrylate;
30 to 80% 2-hydroxy ethyl methacrylate (HEMA);
10 to 20% de-ionized water; and
0.1 to 5% N,N-dimethyl-4-ethylbenzoate.

18. The method of claim 1, wherein said binder system further comprises one of a surfactant, a humectant, or a co-solvent.

19. The method of claim 1, wherein said binder system comprises an ultraviolet (UV) curable binder system.

20. The method of claim 19, further comprising curing said green part by applying ultraviolet (UV) radiation on said green part.

21. A system for solid free-form fabrication of three-dimensional objects comprising:

a particulate blend including metal or metal alloy particulates and a peroxide; and

a jettable binder system including a water soluble monofunctional acrylate-based monomer, a water soluble difunctional acrylate-based monomer, an amine, and water;

wherein said jettable binder system is configured to react on contact with said peroxide and to selectively bind said metal or metal alloy particulates.

22. The system of claim 21, wherein said jettable binder system is disposed in said particulate blend.

23. The system of clam 22, wherein disposing said jettable binder system in said particulate blend initiates a radical polymerization of said water soluble monofunctional acrylate-based monomer and said water soluble difunctional acrylate-based monomer.

24. The system of claim 21, further comprising an ink-jet material dispenser configured to selectively jet said jettable binder system onto said particulate blend.

25. The system of claim 24, wherein said ink-jet material dispenser comprises one of a thermally actuated inkjet dispenser, a mechanically actuated inkjet dispenser, an electrostatically actuated inkjet dispenser, a magnetically actuated inkjet dispenser, a piezoelectrically actuated inkjet dispenser, or a continuous inkjet dispenser.

26. The system of claim 24, further comprising a substrate configured to support said particulate blend in a defined region, said defined region being configured with respect to said ink-jet material dispenser such that said jettable binder system, upon being jetted from said ink-jet material dispenser, contacts said particulate blend.

27. The system of claim 21, wherein said system is configured to apply multiple volumes of said jettable binder system such that each volume of said jettable binder system is bound to at least one adjacent volume.

28. The system of claim 21, further comprising a furnace configured to provide thermal energy to a green part sufficient to effect a thermal binder burnout reaction and a sintering reaction in said green part.

29. The system of claim 28, wherein said furnace is a programmable furnace configured to provide an atmosphere comprising one of oxidizing-air, reducing-hydrogen/nitrogen, dissociated ammonia, or pure hydrogen.

30. The system of claim 29, wherein said atmospheres may be controllably adjusted by said programmable furnace.

31. The system of claim 21, wherein said metal or metal alloy particulates comprises one of a stainless steel alloy, a magnetic alloy, a cobalt alloy, copper, a copper alloy, bronze, brass, tin, gold, iron, silver, platinum, palladium, iridium, titanium, tantalum, chromium alloys, an aluminum alloy, a magnesium alloy, an iron alloy, a nickel alloy, a silicon alloy, a zirconium alloy, a gold alloy, or metal coated ceramic particulates.

32. The system of claim 21, wherein said peroxide comprises one of a methyl ethyl ketone peroxide, a benzoyl peroxide, an acetylacetone peroxide, or a cumene hydroperoxide.

33. The system of claim 21, wherein said water soluble monofunctional acrylate-based monomer comprises one of an ester of acrylic or a methacrylic acid.

34. The system of claim 21, wherein said water soluble difunctional acrylate-based monomer comprises one of a 1,4-butanediol diacrylate, a 1,4-butanediol dimethacrylate, a 1,6-hexamethylene glycol diacrylate, a neopentyl glycol dimethacrylate, a trimethylol propane trimethacrylate, a pentaerythritol triacrylate, a penta-erythritol trimethacrylate, a triethylene glycol triacrylate, a triethylene glycol trimethacrylate, a urethane acrylate, a trimethylol propane triacrylate, or a urethane methacrylate.

35. The system of claim 21, wherein said amine comprises an aromatic amine.

36. The system of claim 35, wherein said aromatic amine comprises one of a dimethylamino benzoate, dihydroxyethyl-p-toluidine dimethylaniline, a diethylaniline, or a dimethylacetamide.

37. The system of claim 21, wherein said particulate blend comprises 99% by weight 434 stainless steel metal-based powder and 1% benzoyl peroxide.

38. The system of claim 21, wherein said particulate blend comprises 95 to 99.5% 410 stainless steel metal-based powder and 1% benzoyl peroxide.

39. The system of claim 21, wherein said binder system comprises:
10 to 40% glycerol dimethacrylate;
30 to 80% 2-hydroxy ethyl methacrylate (HEMA);
10 to 20% de-ionized water; and
0.1 to 5% N,N-dimethyl-4-ethylbenzoate.

40. The system of claim 21, wherein said binder system further comprises one of a surfactant, a humectant, or a co-solvent.

41. The system of claim 21, wherein said binder system further comprises a UV initiator.

42. The system of claim 21, wherein said particulate blend comprises a UV initiator.

43. A metal three-dimensional prototype composition, comprising:

multiple layers of metal-based particulates deposited in contact with one another, each of said multiple layers of metal-based particulates including metal or metal alloy particulates and a peroxide;

wherein said particulate blend was linked by a jettable binder system.

44. The composition of claim 43, wherein said ink-jettable aqueous binder comprises:

a water soluble monofunctional acrylate-based monomer;

a water soluble difunctional acrylate-based monomer;

an amine; and

water.

45. The composition of claim 44, wherein said jettable binder system links said metal-based particulates through a radical polymerization of said water soluble monofunctional acrylate-based monomers and said water soluble difunctional acrylate-based monomer.

46. The composition of claim 43, wherein said composition experienced a thermal binder burnout process and a thermal sintering process.

47. The composition of claim 46, wherein said sintering process coalesced said metal-based particulates.

48. The composition of claim 47, wherein said thermal binder burnout process substantially removed all organic content from said composition.

49. The composition of claim 43, wherein said metal-based particulates comprise one of a stainless steel alloy, a magnetic alloy, a cobalt alloy, copper, a copper alloy, bronze, brass, tin, gold, iron, silver, platinum, palladium, iridium, titanium, tantalum, chromium alloys, an aluminum alloy, a magnesium alloy, an iron alloy, a nickel alloy, a silicon alloy, a zirconium alloy, a gold alloy, or metal coated ceramic particulates.

50. A system for solid free-form fabrication of three-dimensional objects comprising:

a particulate blend including metal or metal alloy particulates and a peroxide;

a jettable binder system including a water soluble monofunctional acrylate-based monomer, a water soluble difunctional acrylate-based monomer, an amine, and water; and

means for jetting said jettable binder;

wherein said jettable binder system is configured to react on contact with said peroxide and to selectively bind said metal or metal alloy particulates.

51. The system of claim 50, wherein said jettable binder system is disposed in said particulate blend.

52. The system of clam 50, further comprising means for applying thermal energy to said selectively bound metal or metal alloy particulates.

53. The system of claim 52, wherein said means for applying thermal energy is configured to perform a thermal binder burnout process and a sintering process on said selectively bound metal or metal alloy particulates.

54. The system of claim 52, further comprising means for regulating an environmental condition of said means for applying thermal energy.

55. The system of claim 54, wherein said means for regulating an environmental condition of said means for applying thermal energy is configured to provide an atmosphere comprising one of oxidizing-air, reducing-hydrogen/nitrogen, dissociated ammonia, or pure hydrogen.

56. The system of claim 55, wherein said atmospheres may be controllably adjusted by said means for applying thermal energy.